Historic, Archive Document

Do not assume content reflects current
scientific knowledge, policies, or practices.

a S21
.A75465
Cop.3

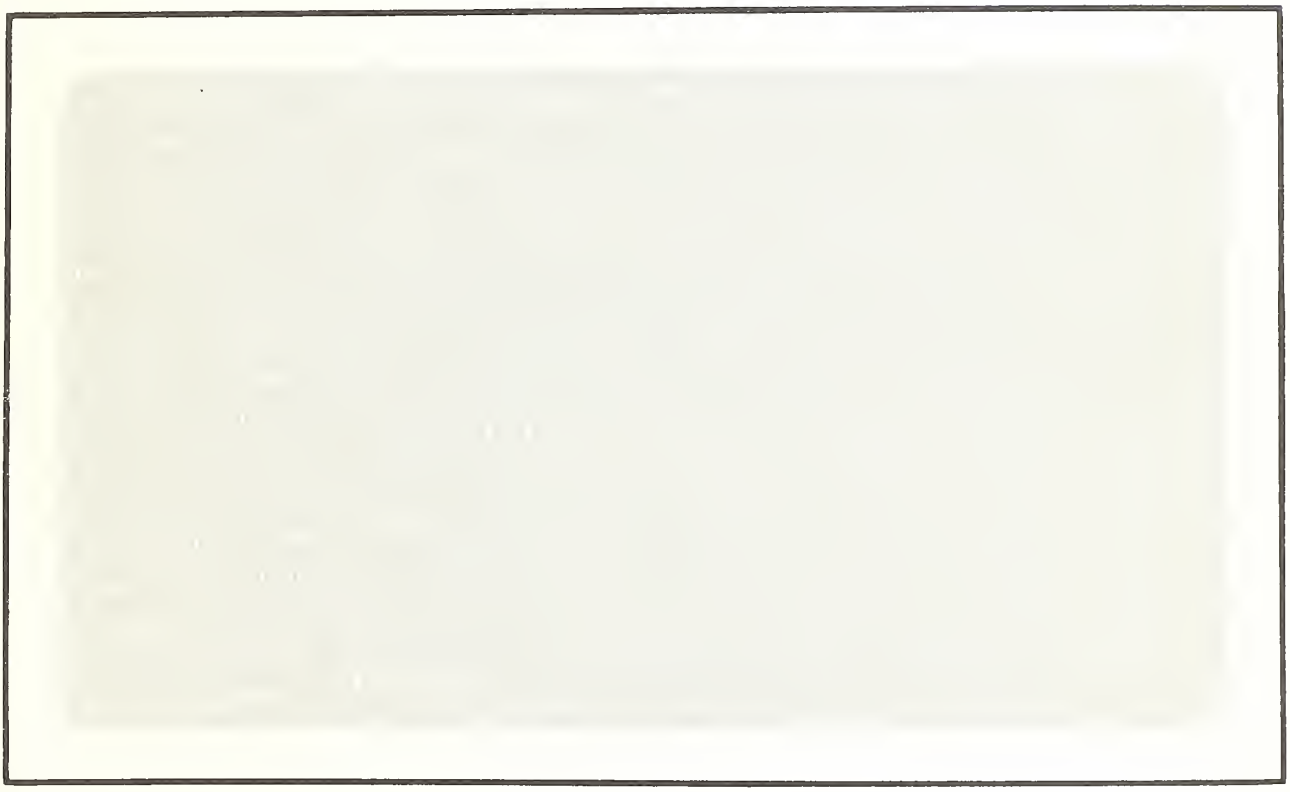
STA/STA

A 106.12:S-17
ISSN 0193-3779

Model Study of a Box-Inlet Chute Spillway and SAF Stilling Basin

U.S.D.A.
NAT'L AGRIC LIBRARY
RECEIVED
NOV 9 '81
PROCUREMENT SECTION
CURRENT SERIAL RECORDS

STA/STA



U.S. Department of Agriculture
Science and Education Administration
Agricultural Reviews and Manuals • ARM–S–17/July 1981

The research reported in this publication was done in cooperation with the Oklahoma Agricultural Experiment Station.

This publication is available from the Water Conservation Structures Laboratory, P.O. Box 551, Stillwater, Okla. 74074.

Science and Education Administration, Agricultural Reviews and Manuals, Southern Series, No. 17, July 1981.

Published by Agricultural Research (Southern Region), Science and Education Administration, U.S. Department of Agriculture, P.O. Box 53326, New Orleans, La. 70153.

CONTENTS

	Page
Abstract	1
Introduction	1
Physical scale model	1
Model test results	2
Discharge rating	2
Riprap	6
Conclusions	10
References	11

ILLUSTRATIONS

Fig.		
1.	Layout and topography of 1:50 model of Boomer Lake spillway, site 23	3
2.	Design of box-inlet spillway and SAF stilling basin used in the model tests	4
3.	Model of box-inlet spillway and SAF stilling basin during construction	5
4.	Completed model of box-inlet spillway and SAF stilling basin	5
5.	Size distribution of riprap used downstream of SAF stilling basin	5
6.	Principal-spillway discharge coefficients versus H/R for tests 1-5	6
7.	Emergency-spillway discharge coefficients versus H/R for tests 7-12	6
8.	Discharge rating curves for Boomer Lake, site 23	7
9.	Initial topography of riprap downstream of SAF stilling basin, after test 7 and before test 8	8
10.	Topography of riprap after an equivalent of 0.42 day with a discharge of 11,990 ft^3/s, after test 10 and before test 11	8
11.	Topography of riprap after an equivalent of 2.65 days with a discharge of 13,770 ft^3/s and 4.42 days with a discharge of 16,440 ft^3/s, after test 11 and before test 12	9
12.	Topography of riprap after an equivalent of 2.95 days with a discharge of 23,160 ft^3/s and 4.12 days with a discharge of 24,630 ft^3/s, after test 12	9
13.	Topography of riprap before minimum tailwater tests, before test 13	10
14.	Topography of riprap after an equivalent of 7.07 days with a discharge of 16,320 ft^3/s and minimum tailwater, after test 13 and before test 14	10
15.	Topography of riprap after an equivalent of 7.07 days with a discharge of 24,713 ft^3/s and minimum tailwater, after test 14	11
16.	Composite of maximum scour depths below end sill for all model tests	11

TABLES

		Page
1.	Summary of model test results	12
2.	Discharge (ft^3/s) ratings for 9.375-inch radius of crest, Boomer Lake spillway, site 23	13
3.	Discharge (ft^3/s) ratings for 8-inch radius of crest, Boomer Lake spillway, site 23	13
4.	Probable maximum flood hydrograph	14

Model Study of a Box-Inlet Chute Spillway and SAF Stilling Basin

By Wendell R. Gwinn[1]

ABSTRACT

A scale model of a proposed box-inlet chute spillway and Saint Anthony Falls (SAF) stilling basin for Boomer Lake, Stillwater, Okla., was tested to determine the head-discharge rating and required riprap. Test results indicate that the riprap should have a mean diameter of 1 foot or more and that the trapezoidal channel at the stilling-basin exit should have 3 : 1 side slopes, with the bottom as wide as the distance between the basin sidewalls and level with the top of the end sill. Some thickening of the riprap would be necessary for the probable maximum flood event, which the spillway could pass without overtopping. Index terms: box-inlet chute spillways, head-discharge ratings, riprap, SAF stilling basins, scale models.

INTRODUCTION

Boomer Lake at Stillwater, Okla., is being considered for incorporation into the flood control plan (Public Law 566) as site 23 for Stillwater Creek, to which Boomer Creek is tributary. The lake serves as a cooling pond for an electric-energy generating station and also as a recreational facility for the city of Stillwater. According to a Phase I inspection report (Parcher 1978), the present concrete spillway (crest elevation 912.2) will pass only 46 percent of the probable maximum flood (PMF) without overtopping the earthen embankment (elevation 917.2).[2] Allowing a 3-foot freeboard would reduce the spillway capacity to only 13 percent of the PMF. Parcher's report recommends, as part of Phase II, the development of a structure that will contain the specified design flood.

Boomer lake is in an urban area, with residences on the west shore. These homes had to be considered in determining both the maximum and minimum water-surface elevations. Thus, the options available to the designers were limited. The Soil Conservation Service (SCS) requested the Water Conservation Structures Laboratory to model test the revised design (earthen embankment elevation 920, maximum flow 24,600 ft^3/s for freeboard hydrograph of 26.09 inches of runoff) to determine both the spillway capacity and necessary riprap below the Saint Anthony Falls (SAF) basin (Blaisdell 1959). The SAF stilling basin was designed for 16,300 ft^3/s (approximately 67 percent of freeboard hydrograph). Ree (1976) had previously determined that excessive scour around the wingwall area of the SAF stilling basin would probably make riprap protection necessary.

PHYSICAL SCALE MODEL

A 1 : 50 scale model of the proposed design and surrounding topography was placed in a model basin 10 feet wide, 40 feet long, and 2.5 feet deep at the Laboratory. A 12-inch pipeline with a capacity of 4 ft^3/s supplied the basin from Lake Carl Blackwell. The scale ratios (Froude modeling criteria) were length, 1 : 50; velocity, 1 : 7.07; time,

[1]Research leader, Water Conservation Structures Laboratory, Science and Education Administration, U.S. Department of Agriculture, P.O. Box 551, Stillwater, Okla. 74074.

[2]Elevations in feet above mean sea level.

1:7.07; and discharge, 1:17,678. The model basin provided a space equivalent to 500 by 1,500 feet in the prototype (fig. 1).

Figure 2 shows the spillway design used in the model tests. The model spillway was built of acrylic plastic and was supported off the basin floor with threaded rods to permit careful leveling (fig. 3). The topography was formed by a 2-inch concrete layer over a compacted sand bed. Elevations were set using a profiler with preset rods that facilitated molding of each 0.1 foot across the basin. A movable riprap bed was used at the outlet of the SAF basin (fig. 4).

Figure 5 shows the size distribution of the riprap used in the downstream channel. In the prototype, the plus-one standard deviation (D_{84}), mean (D_{50}), and minus-one standard deviation (D_{16}) were 13.5, 11.8, and 9.8 inches, respectively. The geometric standard deviation was approximately 1.2 inches. The channel side slopes at the stilling-basin exit, determined by Peralta (1979), were 1 on 3, and the bottom was level with the top of the end sill, with a 0.4 percent slope in the downstream direction (fig. 1). The bottom width was the same as the stilling-basin width.

The box inlet had two crest levels (fig. 2). Principal-spillway flow passed through a 29-foot-long notch with its crest at elevation 910.5, 3.6 feet lower than the emergency-spillway crest at elevation 914.1. The radius of the crest (fig. 2) was 9.375 inches in the prototype (0.19 inch in the model) instead of the proposed 8-inch radius. This change was made to permit using a standard router bit to form the crest. Likewise, the radius of the bridge pier (fig. 2) was 31.25 inches (0.625 inch in the model) instead of the proposed 30-inch radius to permit using a standard shaper cutting tool for forming the pier.

A leaf-type tailgate controlled the tailwater elevation for flows over the emergency spillway ($Q > 765$ ft^3/s). The elevations used were computed by SCS.

MODEL TEST RESULTS

The test results are summarized in table 1. The gage locations are shown in figure 1. Tailwater elevations were preset to computed levels for tests 6-12 using backwater curve information furnished by SCS. Tests 13 and 14 had free outfall at the end of the model, with model topography controlling the tailwater.

Discharge Rating

The head-discharge relationship was analyzed using the equation

$$Q = CLH^{1.5}, \quad (1)$$

where Q=discharge (cubic feet per second),
C=discharge coefficient (feet$^{0.5}$ per second),
L=length of crest (feet),
and H=total head (reservoir elevation minus average crest elevation in feet).

Tests 1-5 (table 1) were principal-spillway flows. The head was divided by the radius of crest (9.375-inch prototype) to give a dimensionless coordinate (H/R) for plotting C in figure 6. The underside of the principal-spillway nappe was filled for all tests. The sharp break (H/R=3.59) was caused by crowding or supporting of the nappe by the floor of the box inlet.

The results of the principal-spillway analysis were used to analyze emergency-spillway flow. The following equation was used to compute the portion of discharge (eq. 1) going through the notch:

$$C = 4.05 - 0.502 \log_{10}(H/R). \quad (2)$$

This amount was subtracted from the total flow discharge, and the remainder was used to determine the emergency-spillway discharge coefficient (C_e) shown in table 1. Therefore, any error in this assumption would be reflected in this coefficient, which was computed with the equation

$$C_e = Q_e / L_e H_e^{1.5}, \quad (3)$$

where Q_e=total discharge minus notch flow (cubic feet per second),
L_e=total average length of crest minus notch length (feet),
and H_e=total head (reservoir elevation minus average emergency crest elevation in feet).

The discharge coefficient (C_e) for test 6 was eliminated because of surface tension effects of the small model head over the emergency-spillway crest. The results of tests 7-12 are shown in figure 7. As in tests 1-5, the sharp break (H_e/R=5.13) was caused by crowding or supporting of the nappe by the floor of the box inlet. Flow over the emergency-

(*Continued on page 6.*)

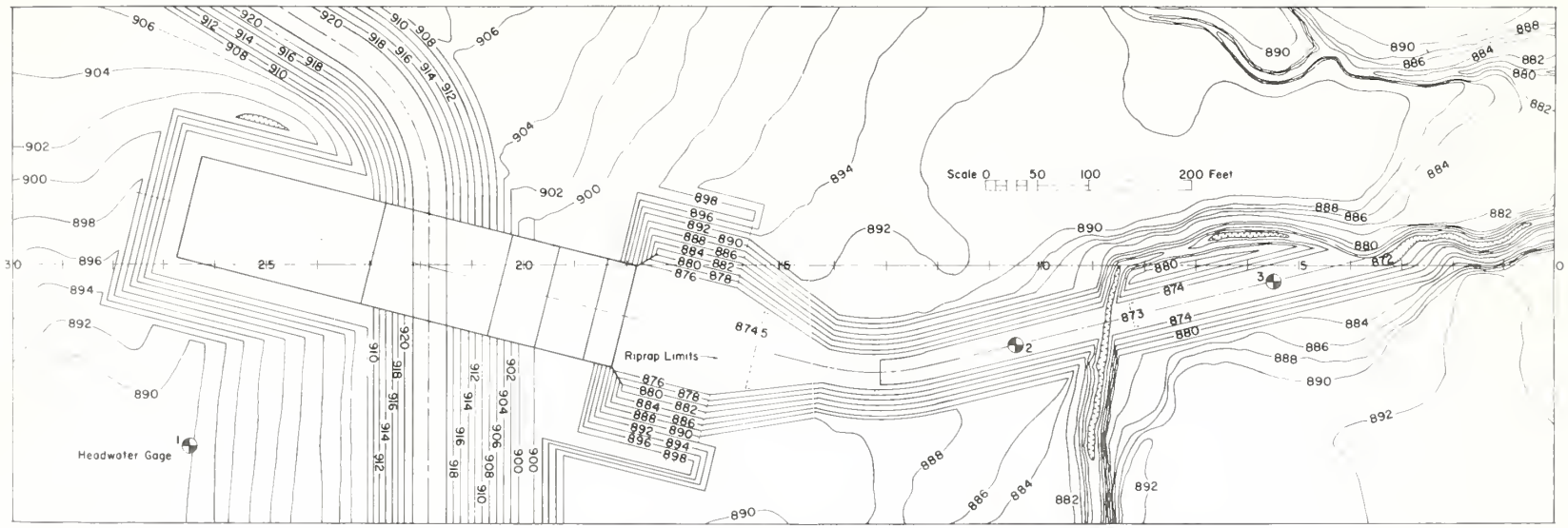


FIGURE 1.—Layout and topography of 1:50 model of Boomer Lake spillway, site 23.

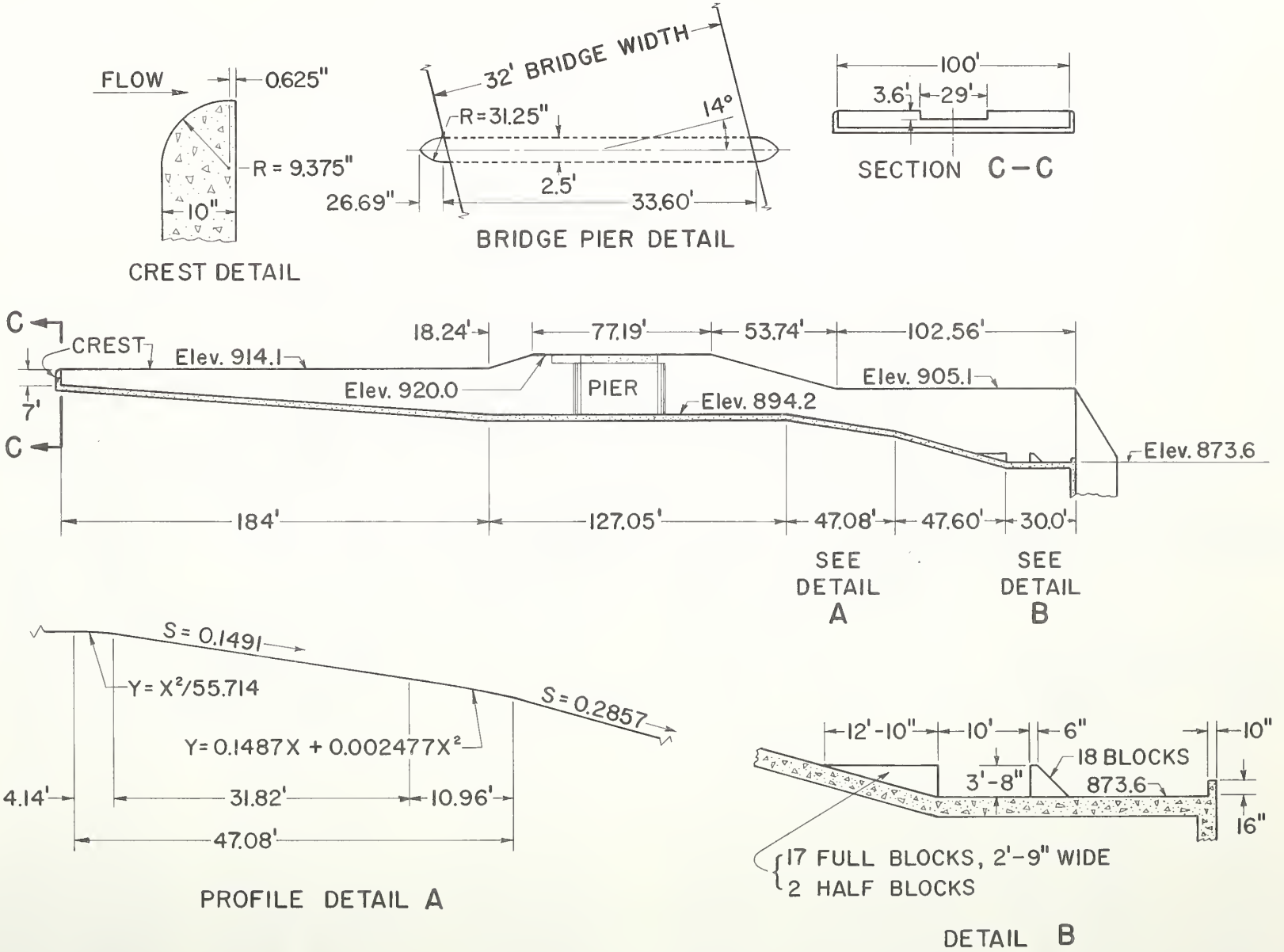


FIGURE 2.—Design of box-inlet spillway and SAF stilling basin used in the model tests.

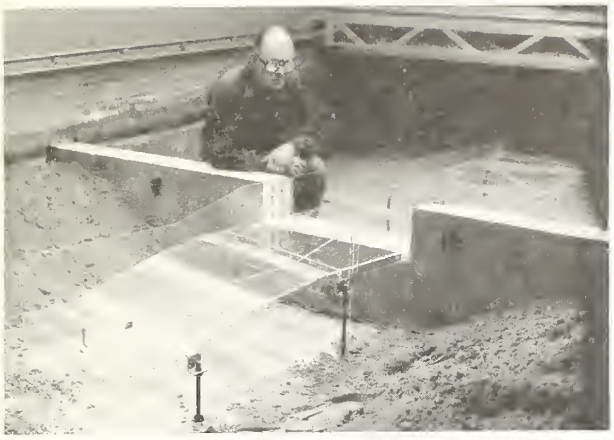


FIGURE 3.—Model of box-inlet spillway and SAF stilling basin during construction.



FIGURE 4.—Completed model of box-inlet spillway and SAF stilling basin.

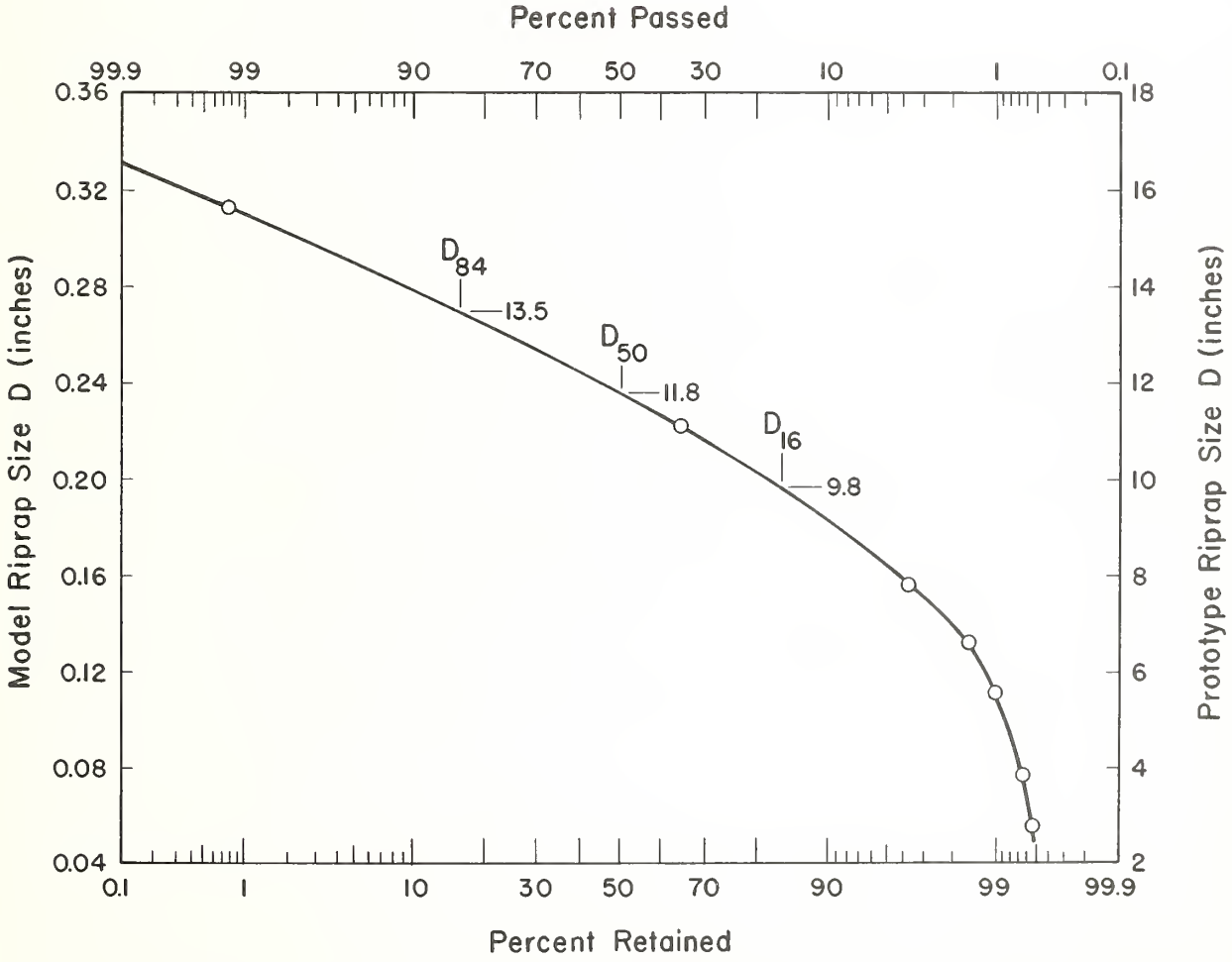


FIGURE 5.—Size distribution of riprap used downstream of SAF stilling basin.

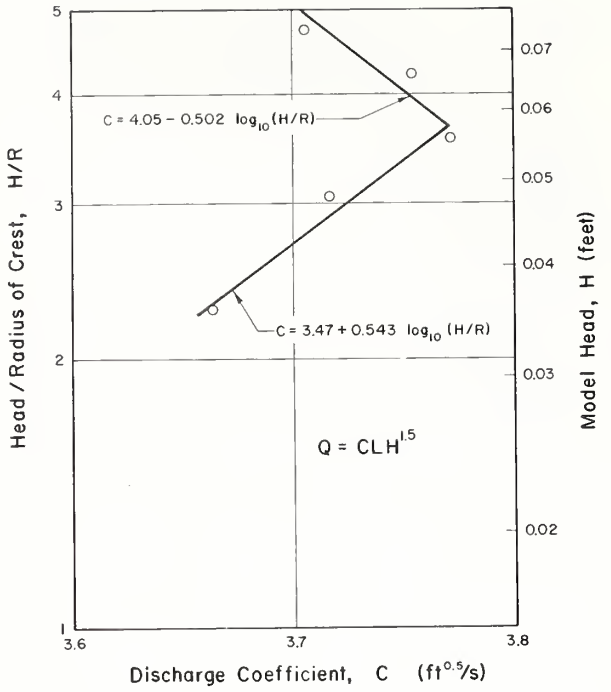


FIGURE 6.—Principal-spillway discharge coefficients versus H/R for tests 1-5.

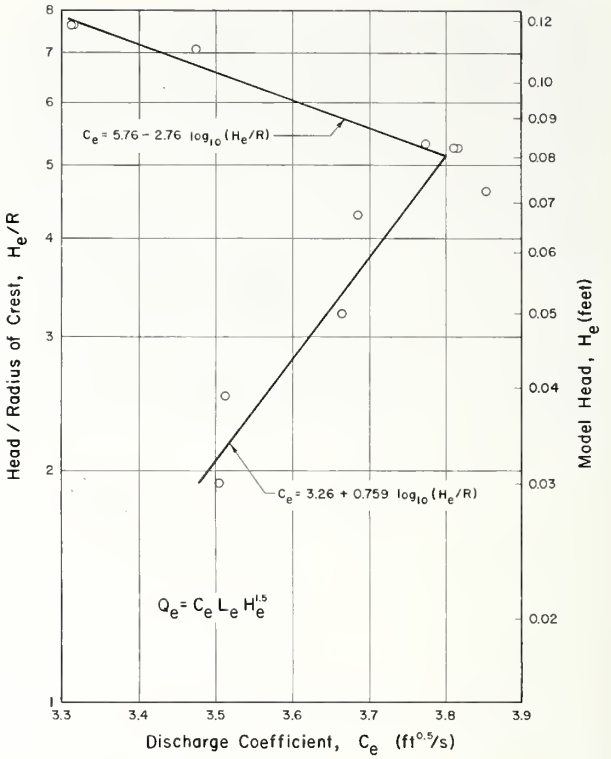


FIGURE 7.—Emergency-spillway discharge coefficients versus H/R for tests 7-12.

spillway crest was fully vented (springing free) for $H_e/R < 5$. The underside of the nappe for both spillways was filled for all tests with $H_e/R > 7$. Venting the nappe would not have caused the flow to spring free.

The equations in figures 6 and 7 were used to compute the discharge ratings for the 9.375-inch radius of crest (table 2). The discharge rate of 24,840 ft^3/s for maximum pool elevation (920 feet) exceeded the discharge rate of 24,606 ft^3/s as specified by the SCS freeboard hydrograph design. These equations were also used to compute the discharge ratings for an 8-inch radius of crest (table 3). Here the maximum discharge was 95.8 percent of the SCS freeboard hydrograph design. The two ratings can be compared with the pre-model SCS design rating in figure 8.

The PMF and storage inflow rates from the report by Parcher (1978) were used with the rating tables to compute the hydrograph shown in table 4. With either crest radius, the spillway would have passed the PMF without overtopping the embankment. However, no freeboard for wave action for this extreme flow event would have been provided.

Riprap

As previously stated, the size distribution of the riprap downstream of the SAF stilling basin is shown in figure 5. The shape of the initial erodible riprap area after a flow of 4,011 ft^3/s is shown in figure 9. Flows of less than 8,000 ft^3/s (prototype) caused no observable movement of the stones. The first movement of riprap was just downstream of the end sill after an equivalent of 0.42 day with a discharge of 11,990 ft^3/s. These minor changes may be determined by comparing figure 10 with figure 9.

Test 11 (table 1) was intended to represent 7.07 days (24 hours for the model) at the design flow rate for the SAF stilling basin (16,300 ft^3/s, 67 percent of freeboard hydrograph). However, during the night while the model was unattended, the flow control shifted and reduced the flow to 13,770 ft^3/s for 2.65 days (9 hours for the model) of the test. The flow was reset to 16,330 ft^3/s the next morning for the remaining 1.47 days (5 hours for the model). The resulting topography is shown in figure 11. The maximum scour depth was 2.5 feet just down-

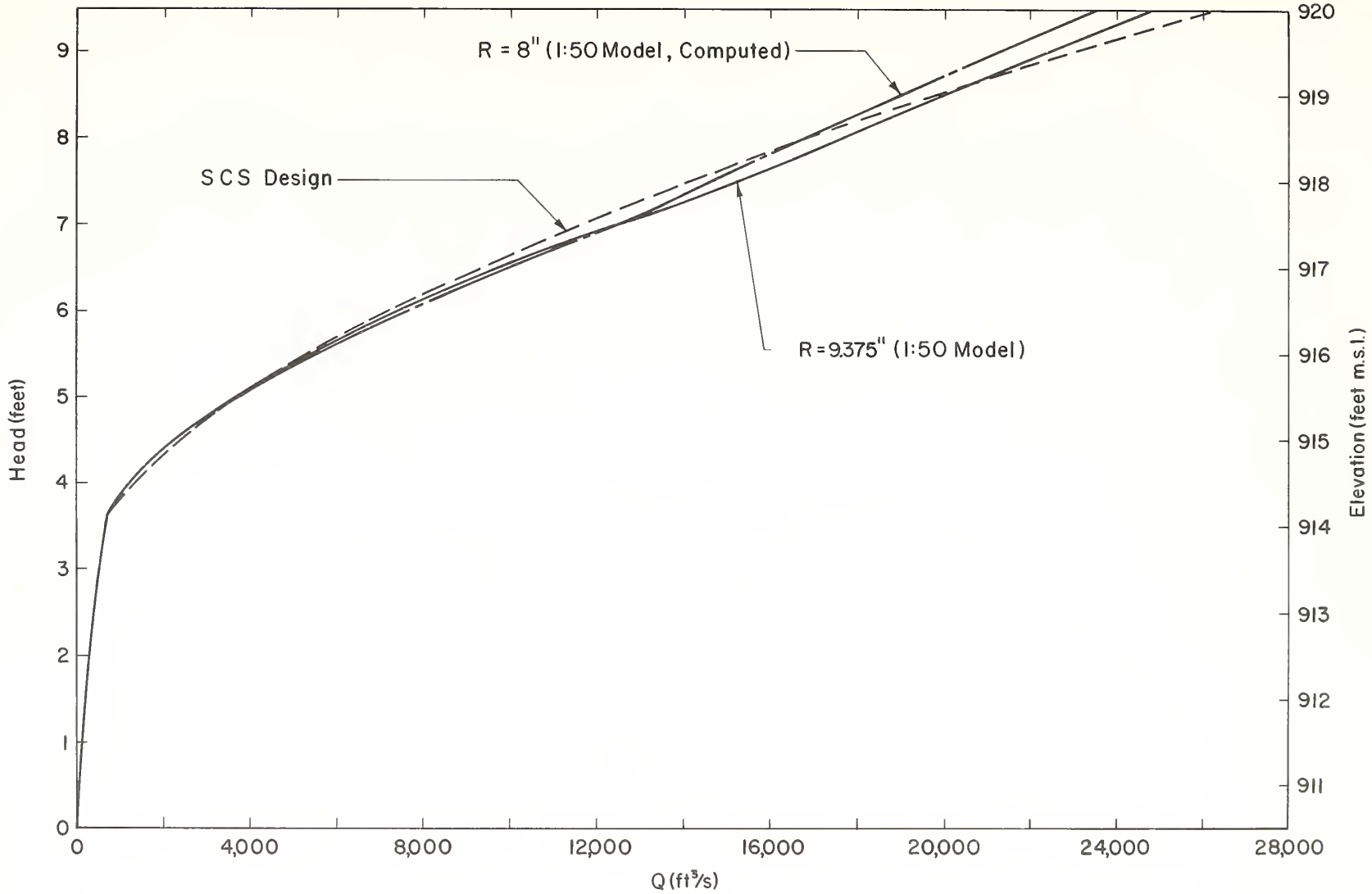


FIGURE 8.—Discharge rating curves for Boomer Lake, site 23.

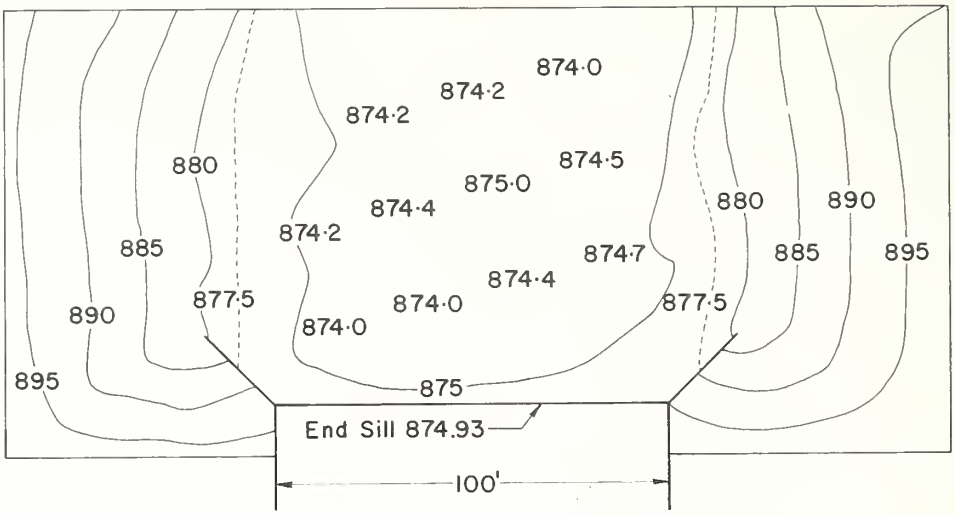


FIGURE 9.—Initial topography of riprap downstream of SAF stilling basin, after test 7 and before test 8.

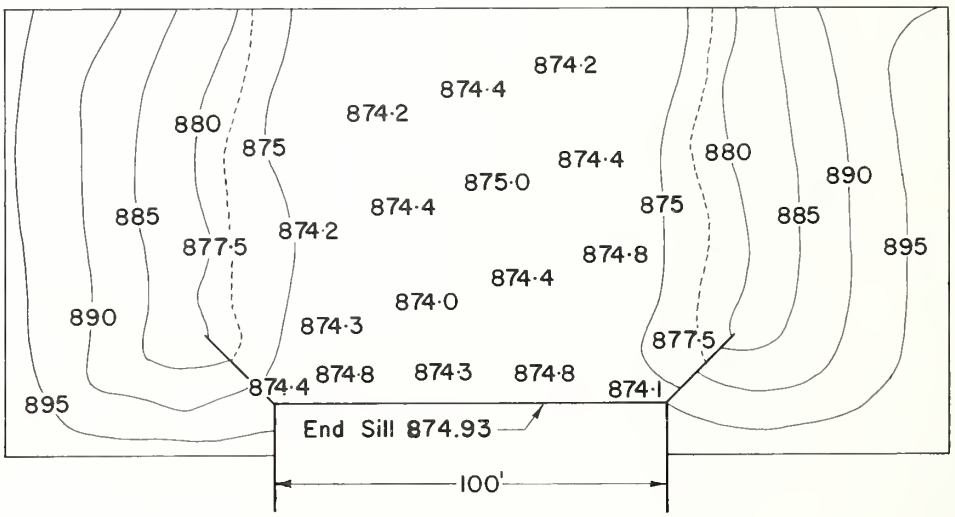


FIGURE 10.—Topography of riprap after an equivalent of 0.42 day with a discharge of 11,990 ft^3/s, after test 10 and before test 11.

stream of the sidewalls. The changes in topography during this test may be determined by comparing figure 11 with figure 10. The design flow-rate test was repeated in test 15 (table 1). The flow-control shift (11,240 ft^3/s) in test 15 was caused by two large catfish lodged in the entrance to the water supply line. The scour pattern after test 15 (total scour time 7.07 days, 16,320 ft^3/s) was approximately the same as that shown in figure 11.

Test 12 (table 1) was intended to represent 7.07 days (24 hours for the model) at the computed maximum flow rate (24,600 ft^3/s). However, similar to test 11, the flow control shifted during the night and reduced the flow to 23,160 ft^3/s for 2.95 days (10 hours for the model). The topography after this test is shown in figure 12. The maximum scour was 7 feet, with the riprap from the scour holes deposited just downstream. The maximum flow-rate test was repeated in test 16 (table 1) with a total scour time of 7.07 days (24 hours for the model). The scour pattern was approximately the same as that shown in figure 12.

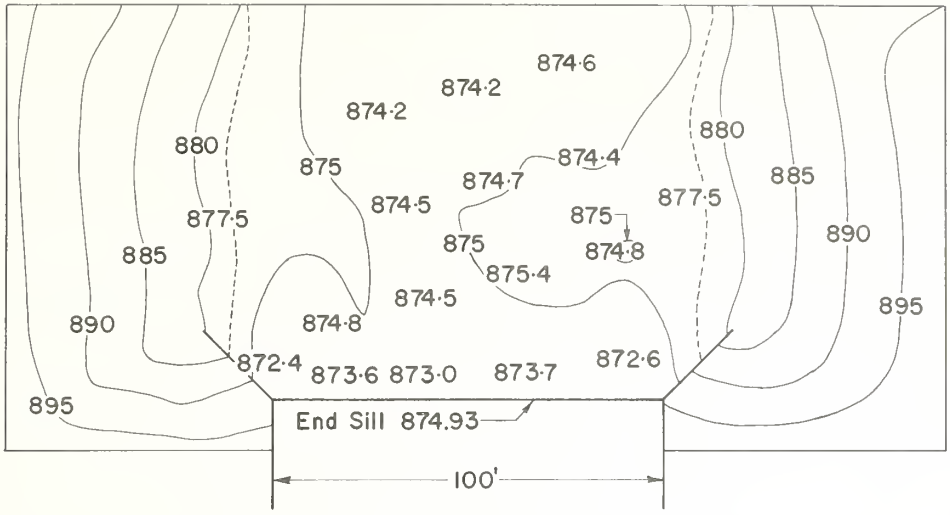


FIGURE 11.—Topography of riprap after an equivalent of 2.65 days with a discharge of 13,770 ft³/s and 4.42 days with a discharge of 16,440 ft³/s, after test 11 and before test 12.

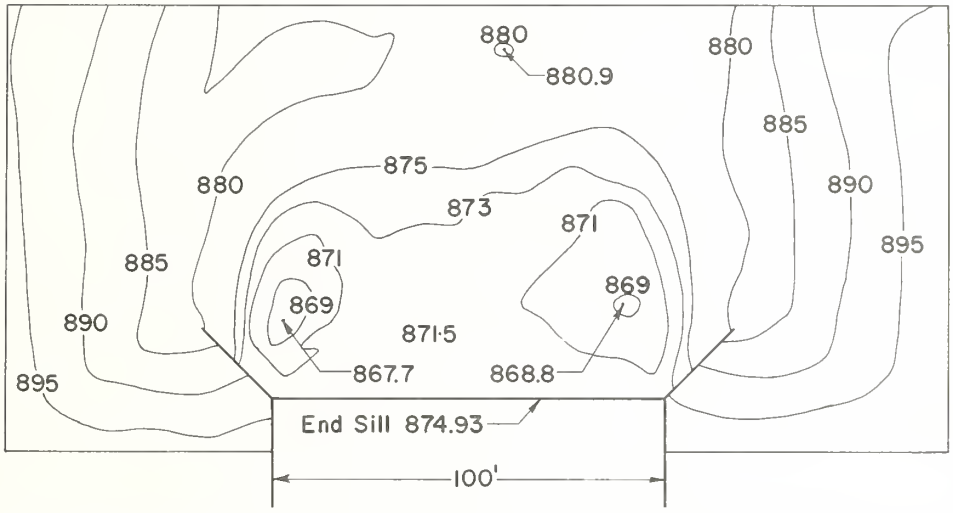


FIGURE 12.—Topography of riprap after an equivalent of 2.95 days with a discharge of 23,160 ft³/s and 4.12 days with a discharge of 24,630 ft³/s, after test 12.

In tests 6-12, the tailwater was controlled with the tailgate and set to levels computed by SCS. To obtain data for use in the event of future downstream degradation, tests with minimum tailwater were run. Before these tests were conducted, however, the topography of the riprap was reshaped as shown in figure 13. The tailgate was lowered, thus the model had free outfall at the downstream end. Setting the flow equal to the design discharge of 16,320 ft³/s for an equivalent of 7.07 days resulted in minimum tailwater 4.1 feet below normal tailwater. The topography after this flow is shown in figure 14. The maximum scour depth was 3 feet. However, the scour overall was less for normal tailwater (fig. 10). The hydraulic jump stayed within the stilling basin, and the stilling-basin performance was good even with the lowered tailwater.

The maximum flow (24,780 ft³/s) with minimum tailwater was run without reshaping the riprap topography of the design flow with minimum tailwater. The resulting minimum tailwater was 5.1 feet below normal tailwater for the same discharge.

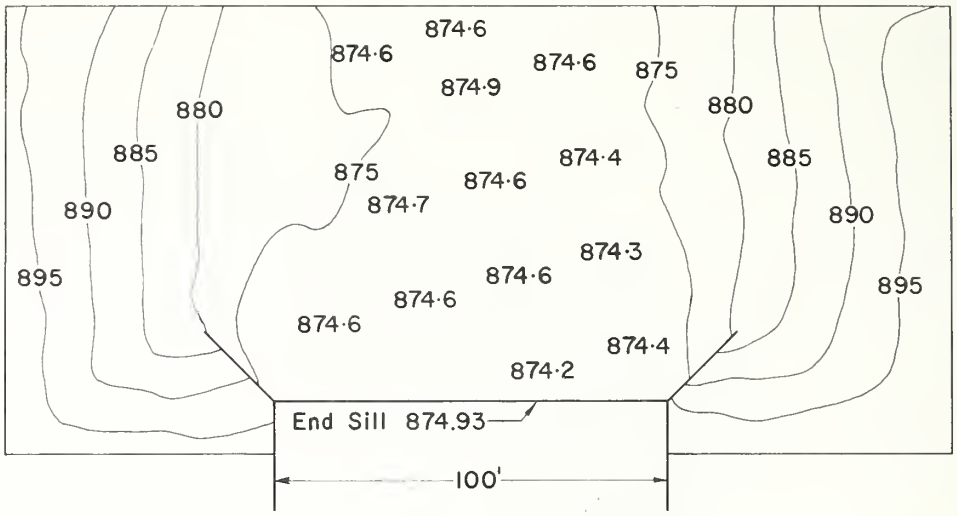


FIGURE 13.—Topography of riprap before minimum tailwater tests, before test 13.

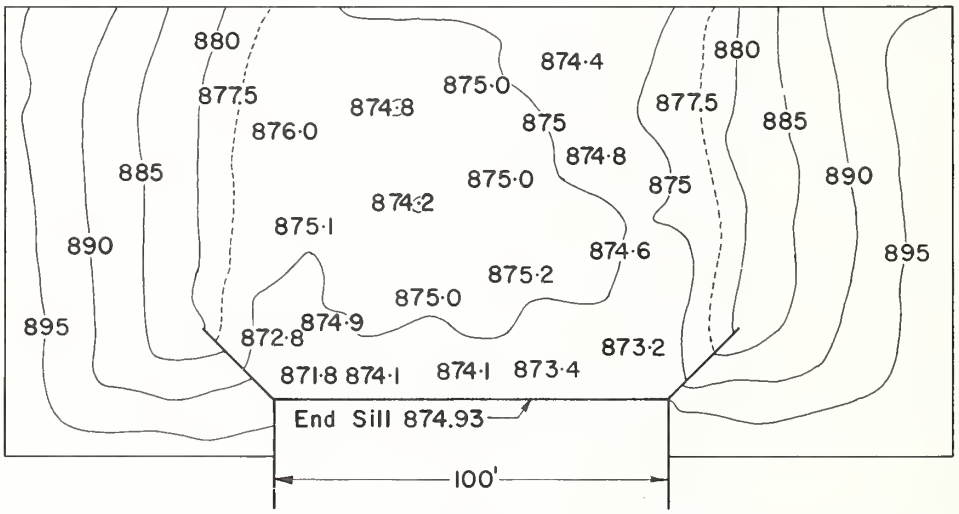


FIGURE 14.—Topography of riprap after an equivalent of 7.07 days with a discharge of 16,320 ft^3/s and minimum tailwater, after test 13 and before test 14.

The hydraulic jump within the stilling basin was almost eliminated, and wave action along the downstream banks was increased. The riprap topography after an equivalent of 7.07 days with the maximum flow is shown in figure 15. Maximum scour was 3.5 feet. A comparison of figure 15 with figure 12 shows that there was less scour for the lowered tailwater and that the scour hole moved farther downstream. Figure 16 shows a composite of maximum scour depths below the end sill for all tests.

CONCLUSIONS

The spillway will pass the probable maximum flood without overtopping the embankment. However, no freeboard for wave action will be provided. Riprap with a mean diameter of 1 foot will provide the needed protection for the SAF basin. The riprapped trapezoidal channel should have 3 : 1 side slopes. Its bottom should be as wide as the distance between the sidewalls (100 feet) and level with the top of the end sill. The channel should

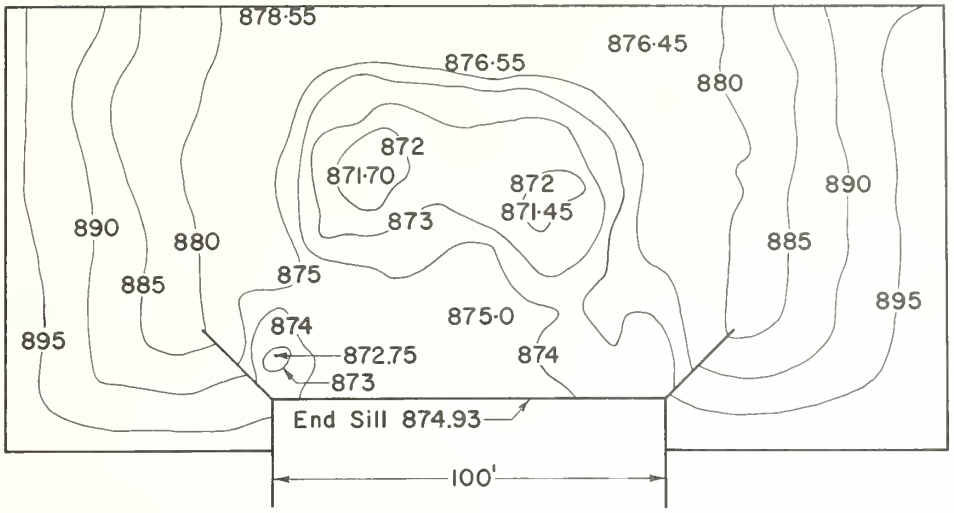


FIGURE 15.—Topography of riprap after an equivalent of 7.07 days with a discharge of 21,713 ft³/s and minimum tailwater, after test 14.

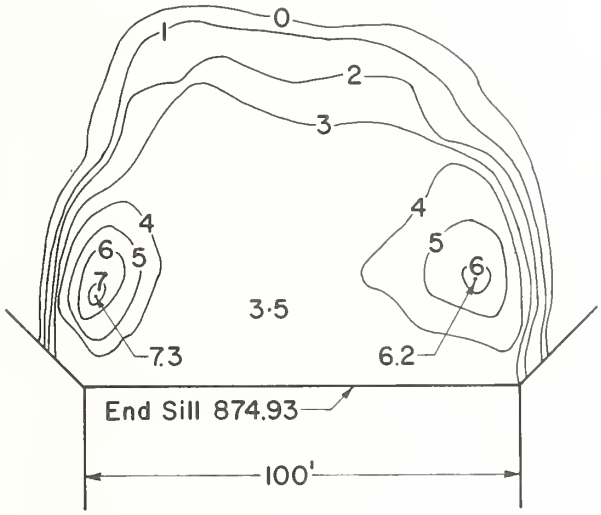


FIGURE 16.—Composite of maximum scour depths below end sill for all model tests.

be excavated to a depth equal to the maximum scour depth (fig. 16) plus normal riprap thickness (2 feet). By providing extra thickness in the area of scour, the basin will form its own natural shape if and when the extreme flows occur. However, the scoured rock can be expected to deposit in the downstream channel.

REFERENCES

Blaisdell, F. W.
1959. The SAF stilling basin. U.S. Dep. Agric. Agric. Handb. 156, 16 pp.

Parcher, J. V.
1978. Phase I, inspection report, National Dam Safety

Program for Boomer Lake—dam and spillway, Payne County, Okla., inventory no. OK01389. Available from Oklahoma Water Resources Board, P.O. Box 53585, Oklahoma City 73152.

Peralta, R. C.
1979. Riprap design for SAF stilling basins. 131 pp. Ph.D. thesis, Oklahoma State University, Stillwater.

Ree, W. O.
1976. Comparison of chute and stilling basin performance for three different drop box inlets. U.S. Agric. Res. Serv. [Rep.] ARS-S-126, 11 pp.

Table 1.—Summary of model test results

Test No.	Model time (h:min)	Prototype time (d)	Spillway discharge, Q (ft^3/s)	Pool, gage 1 (ft)	Tailwater		Principal spillway[1]		Emergency spillway[2]	
					Gage 2 (ft)	Gage 3 (ft)	H/R	C ($ft^{0.5}/s$)	H_e/R	C_e ($ft^{0.5}/s$)
1	0:40	0.196	763	914.38	881.63	881.62	4.73	3.706		
2	0:35	.172	651	913.98	881.18	881.17	4.22	3.755		
3	0:40	.196	504	913.46	880.48	880.47	3.54	3.772		
4	1:10	.344	399	913.08	879.93	879.92	3.06	3.717		
5	0:50	.246	253	912.47	878.84	878.95	2.28	3.664		
6	1:15	.368	2,019	915.05	887.60	887.57	5.59	(3.679)	1.22	2.556
7	0:40	.196	4,011	915.60	890.30	890.30	6.29	(3.653)	1.92	3.506
8	0:40	.196	5,567	916.05	893.41	893.43	6.87	(3.634)	2.50	3.513
9	0:40	.196	7,981	916.60	894.00	894.00	7.58	(3.612)	3.21	3.667
10	1:25	.417	11,990	917.45	895.75	895.70	8.67	(3.583)	4.29	3.687
11	10:00	2.946	16,440	918.20	897.26	897.25	9.63	(3.560)	5.26	3.818
	9:00	2.652	13,770	917.70	896.88	896.85	8.99	(3.575)	4.62	3.854
	2:30	.737	16,330	918.19	897.27	897.25	9.61	(3.560)	5.24	3.812
	2:30	.737	16,600	918.26	897.34	897.33	9.70	(3.558)	5.33	3.776
12	7:00	2.062	24,610	920.00	899.89	899.82	11.94	(3.513)	7.56	3.313
	10:00	2.946	23,160	919.65	899.81	899.71	11.48	(3.522)	7.11	3.428
	3:30	1.031	24,620	920.00	899.98	899.84	11.94	(3.513)	7.56	3.316
	3:30	1.031	24,620	920.00	900.02	899.87	11.94	(3.513)	7.56	3.316
13	12:00	3.536	16,200	918.15	892.90	893.17	9.56	(3.562)	5.19	3.838
	12:00	3.536	16,320	918.20	892.95	893.20	9.63	(3.560)	5.26	3.785
14	12:00	3.536	24,780	919.99	894.12	894.72	11.92	(3.513)	7.55	3.350
	12:00	3.536	24,710	920.00	894.18	894.76	11.94	(3.513)	7.56	3.330
15	1:00	.295	16,280	918.10	897.25	897.30	9.50	(3.563)	5.13	3.932
	15:24	4.537	16,320	918.23	897.35	897.30	9.67	(3.559)	5.29	3.741
	7:23	2.175	11,240	917.25	896.40	896.40	8.41	(3.589)	4.04	3.782
	3:48	1.120	16,340	918.25	897.29	897.30	9.69	(3.559)	5.31	3.722
	3:48	1.120	16,330	918.35	897.35	897.34	9.82	(3.556)	5.45	3.570
16	6:00	1.768	24,590	920.06	899.94	899.81	12.01	(3.512)	7.64	3.255
	6:00	1.768	24,590	920.07	900.03	899.87	12.02	(3.512)	7.65	3.251
	6:00	1.768	24,660	920.00	900.00	899.83	11.94	(3.513)	7.56	3.322
	6:00	1.768	25,030	920.13	900.08	899.88	12.10	(3.510)	7.72	3.263

[1] H/R=Principal-spillway head divided by radius of crest. C=Principal-spillway discharge coefficient; numbers in parentheses were computed using results of tests 1-3.

[2] H_e/R=Emergency-spillway head divided by radius of crest. C_e=Emergency-spillway discharge coefficient.

Table 2.—Discharge (ft^3/s) ratings for 9.375-inch radius of crest, Boomer Lake spillway, site 23

Elevation (ft m.s.l.)	Elevation (tenths of a foot)									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
910	0	0	0	0	0	0	3	8	15	24
911	34	46	58	72	87	102	119	136	154	173
912	193	214	235	257	279	303	327	351	377	403
913	429	456	484	512	539	566	593	621	649	678
914	707	736	802	906	1,039	1,195	1,373	1,570	1,784	2,015
915	2,263	2,525	2,803	3,094	3,399	3,717	4,048	4,392	4,748	5,116
916	5,495	5,886	6,289	6,702	7,127	7,562	8,007	8,464	8,930	9,406
917	9,893	10,389	10,895	11,411	11,937	12,472	13,016	13,569	14,132	14,704
918	15,285	15,875	16,348	16,807	17,268	17,731	18,196	18,662	19,130	19,599
919	20,069	20,541	21,014	21,488	21,963	22,440	22,918	23,397	23,877	24,358
920	24,840									

Table 3.—Discharge (ft^3/s) ratings for 8-inch radius of crest, Boomer Lake spillway, site 23

Elevation (ft m.s.l.)	Elevation (tenths of a foot)									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
910	0	0	0	0	0	0	3	8	16	25
911	35	46	59	73	88	103	120	138	156	175
912	195	216	237	259	282	306	330	355	381	407
913	431	456	482	508	534	561	588	616	643	672
914	700	729	795	901	1,035	1,193	1,373	1,572	1,789	2,023
915	2,273	2,539	2,819	3,114	3,422	3,744	4,079	4,427	4,787	5,159
916	5,543	5,939	6,346	6,764	7,194	7,634	8,085	8,546	9,018	9,500
917	9,992	10,494	11,006	11,528	12,059	12,600	13,050	13,473	13,898	14,325
918	14,753	15,182	15,613	16,046	16,479	16,915	17,351	17,788	18,227	18,667
919	19,108	19,549	19,992	20,436	20,881	21,326	21,772	22,219	22,667	23,116
920	23,565									

Table 4.—Probable maximum flood hydrograph[1]

Time (h)	Inflow (ft^3/s)	9.375-inch radius of crest		8-inch radius of crest	
		Outflow (ft^3/s)	Elevation (ft m.s.l.)	Outflow (ft^3/s)	Elevation (ft m.s.l.)
0.0	0	0	910.50	0	910.50
0.5	161	0	910.51	0	910.51
1.0	161	0	910.53	0	910.53
1.5	250	1	910.56	1	910.56
2.0	536	4	910.62	4	910.62
2.5	931	9	910.72	9	910.72
3.0	1,366	22	910.88	22	910.88
3.5	1,868	46	911.10	46	911.10
4.0	2,364	84	911.38	85	911.38
4.5	2,775	138	911.71	139	911.71
5.0	3,092	207	912.07	209	912.07
5.5	3,335	291	912.45	294	912.45
6.0	3,521	387	912.84	391	912.84
6.5	3,734	495	913.24	492	913.24
7.0	4,377	610	913.66	604	913.66
7.5	5,050	756	914.14	749	914.14
8.0	6,191	1,489	914.66	1,490	914.66
8.5	8,636	2,917	915.24	2,935	915.24
9.0	12,624	5,304	915.95	5,350	915.95
9.5	20,467	9,455	916.91	9,500	916.90
10.0	23,173	14,647	917.89	14,325	917.90
10.5	24,889	18,289	918.62	17,657	918.67
11.0	26,757	21,014	919.20	20,436	919.30
11.5	26,833	23,110	919.64	22,578	919.78
12.0	24,057	23,925	919.81	23,565	920.00
12.5	20,065	23,253	919.67	23,026	919.88
13.0	16,470	21,488	919.30	21,415	919.52
13.5	13,454	19,130	918.80	19,196	919.02
14.0	10,636	16,577	918.25	16,740	918.46
14.5	8,238	13,514	917.69	14,196	917.87
15.0	6,327	10,895	917.20	11,633	917.32
15.5	4,863	8,789	916.77	9,161	916.83
16.0	3,734	7,084	916.39	7,281	916.42
16.5	2,865	5,729	916.06	5,819	916.07
17.0	2,195	4,676	915.78	4,714	915.78
17.5	1,683	3,815	915.53	3,844	915.53
18.0	1,292	3,124	915.31	3,144	915.31
18.5	982	2,580	915.12	2,566	915.11
19.0	743	2,137	914.95	2,146	914.95
19.5	553	1,784	914.80	1,789	914.80
20.0	396	1,509	914.67	1,510	914.67
20.5	263	1,282	914.55	1,263	914.54
21.0	116	1,084	914.43	1,080	914.43
21.5	69	944	914.33	926	914.32
22.0	40	830	914.23	824	914.23
22.5	21	756	914.14	749	914.14
23.0	6	725	914.06	718	914.06
23.5	0	698	913.97	692	913.97
24.0	0	675	913.89	669	913.89

[1]Hydrograph computed using inflow rates from report by Parcher (1978).

U.S. GOVERNMENT PRINTING OFFICE: 1981—771-039/3C

U.S. DEPARTMENT OF AGRICULTURE
SCIENCE AND EDUCATION ADMINISTRATION
P. O. BOX 53326
NEW ORLEANS, LOUISIANA 70153

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U. S. DEPARTMENT OF
AGRICULTURE
AGR 101

